

We claim:

1. An imaging system comprising:
an ultrasound console having an input; and
an interferometer comprising a detector with an output coupled to the input of the
5 ultrasound processor to provide data to the ultrasound console;
wherein the ultrasound console processes data provided by the interferometer to
form an image for display.
2. The imaging system of claim 1, wherein the input of the ultrasound console and
the output of the detector are adapted to be selectively coupled.
3. The imaging system of claim 2, further comprising an ultrasound device with an
output adapted to be selectively coupled to the input of the ultrasound console.
4. The imaging system of claim 1, wherein the ultrasound console further comprises
a second input and the system further comprises an ultrasound device with an output coupled to
the second input.
5. The imaging system of claim 1, wherein the interferometer comprises a catheter.
6. The imaging system of claim 3, wherein the ultrasound device comprises a
catheter.
7. The imaging system of claim 1, wherein the detector is a multi-element photo
20 detector having a plurality of parallel outputs, the system further comprising:
a parallel to serial converter electrically coupled between the output of the detector and the input
of the ultrasound console, the parallel to serial converter comprising a plurality of inputs, each

input being coupled to a respective one of the plurality of outputs of the detector, to convert the parallel data output by the plurality of outputs of the detector into serial data, the parallel to serial converter having an output coupled to the input of the ultrasound console to provide the serial data to the ultrasound console to process into an image.

5 8. The imaging system of claim 7, wherein the ultrasound console is adapted to process analog serial data and the parallel to serial converter is adapted to provide analog serial data to the ultrasound console.

9. The imaging system of claim 7, wherein the ultrasound console is adapted to process digital serial data and the parallel to serial converter is adapted to provide digital serial data to the ultrasound console.

10. The imaging system of claim 7, wherein the interferometer comprises two multi-element photo detectors, each comprising a plurality of parallel outputs coupled to the parallel to serial converter.

11. The imaging system of claim 1, wherein the interferometer further comprises:

5 a light source;

means for creating a sample light beam and a reference light beam from light from the light source;

means for conveying the sample light beam to a sample;

20 means for introducing a time delay into at least one of a second sample light beam received from the sample and the reference light beam; and

means for combining the second sample light beam with the reference light beam to form a combined light beam for detection by the detector.

12. The imaging system of claim 11, wherein the means for combining the second sample light beam and the reference light beam is a beam splitter.

13. The imaging system of claim 11, wherein the means for introducing a time delay and the means for combining the second sample light beam and the reference light beam is a diffraction grating.

14. The imaging system of claim 11, wherein:
the means for introducing a time delay is a diffraction grating that introduces the time delay to the reference light beam; and

the means for combining the second sample light beam and the reference light beam is a beam splitter.

15. The imaging system of claim 11, wherein the means for forming the sample and reference light beams is a first beam splitter and the means for combining the second sample light beam and the reference light beam is a second beam splitter.

16. The imaging system of claim 1, wherein the interferometer further comprises:
a low coherence light source;
a first beam splitter in communication with the light source to split light from the light source into a first sample light beam to be directed onto a sample and a reference light beam;

a diffraction grating in communication with the first beam splitter to receive the reference light beam from the first beam splitter and to diffract the reference light beam; and

a second beam splitter positioned to receive a second sample light beam from the sample, the second beam splitter being in communication with the diffraction grating to receive the diffracted reference light beam, wherein the second sample light beam and the diffracted

reference light beam are combined in the second beam splitter to form a combined light beam;
and

a detector positioned to receive the combined light beam from the second beam splitter.

5 17. The imaging system of claim 16, wherein at least one of the first beam splitter and the second beam splitter is a non 50/50 beam splitter.

18. The imaging system of claim 17, wherein:

the first beam splitter is an approximately 50/50 beam splitter; and

the second beam splitter directs more than half of the light energy in the second sample light beam into the combined beam and directs less than half of the light energy in the reference light beam into the combined beam.

19. The imaging system of claim 18, wherein the second beam splitter directs substantially more than half of the light energy in the second sample light beam into the combined light beam and directs substantially less than half of the light energy in the reference light beam into the combined beam.

20. The imaging system of claim 19, wherein the diffraction grating is a reflective diffraction grating, a transparent diffraction grating or an acousto optic modulator.

21. The imaging system of claim 18, wherein the detector is a multi-element photo detector comprising a plurality of parallel outputs, the system further comprising:

20 a parallel to serial converter electrically coupled between the output of the detector and the input of the ultrasound console, the parallel to serial converter comprising a plurality of inputs, each input being coupled to a respective one of the plurality of outputs of the

detector, to convert the parallel data output by the plurality of outputs of the detector into serial data,

the parallel to serial converter having an output coupled to the input of the ultrasound console to provide the serial data to the ultrasound console to process into an image.

5 22. The imaging system of claim 17, wherein the first beam splitter directs more than half of the light energy received from the light source into the sample light beam and less than half of the light energy received from the light source into the reference light beam.

23. The imaging system of claim 22, further comprising an optical circulator, wherein the sample light beam is directed to the sample through the optical circulator and the second sample light beam is directed to the second beam splitter through the optical circulator.

24. The imaging system of claim 23, wherein the second beam splitter directs substantially more than half of the light energy received from the light source into the sample light beam and substantially less than half of the light energy received from the light source into the reference light beam.

5 25. The imaging system of claim 24, wherein the second beam splitter is an approximately 50/50 beam splitter and the second sample light beam and the reference light beam are combined in the second beam splitter to form first and second combined light beams, the first light beam being detected by the first detector; and

the interferometer further comprises a second detector to detect the second light
20 beam.

26. The imaging system of claim 25, wherein the first and second detectors are each multi-element photo detectors comprising a plurality of parallel outputs, the system further comprising:

a parallel to serial converter electrically coupled between the output of the detector and the input of the ultrasound console, the parallel to serial converter comprising a plurality of inputs, each input being coupled to a respective one of the plurality of outputs of the detector, to convert the parallel data output by the plurality of outputs of the detector into serial data,

the parallel to serial converter having an output coupled to the input of the ultrasound console to provide the serial data to the ultrasound console to process into an image.

27. The imaging system of claim 16, further comprising a focusing lens to focus the sample light beam onto the sample and to focus the second sample light beam.

28. An imaging system comprising:

an ultrasound console having an input;

an interferometer comprising:

a low coherence light source;

a first fiber optic beam splitter;

a first optical path optically coupling the light source to the first beam splitter, wherein the first beam splitter splits light received from the light source into a sample light beam and a reference light beam;

a second optical path optically coupling the first beam splitter to a sample and coupling a second sample light beam from the sample to the first beam splitter;

a second beam splitter;

a third optical path optically coupling the first beam splitter to the second beam splitter to convey the second sample light beam, at least in part, from the first beam splitter to the second beam splitter;

a diffraction grating;

a fourth optical path optically coupling the first beam splitter to the diffraction grating to convey the reference light beam, at least in part, to the diffraction grating;

wherein the second beam splitter is positioned to receive the diffracted reference light beam and the reference light beam and the second sample light beam are combined in the second beam splitter to form a combined light beam; and

a multi-element photo detector having a plurality of parallel outputs, the multi-element photo detector being positioned to receive the combined light beam;

the system further comprising a parallel to serial converter comprising a plurality of inputs, each input being coupled to a respective one of the plurality of outputs of the detector, to convert the parallel data output by the plurality of outputs of the detector into serial data,

the parallel to serial converter having an output coupled to the input of the ultrasound console to provide the serial data to the ultrasound console to process into an image.

29. The imaging system of claim 28, wherein:

the first beam splitter is an approximately 50/50 beam splitter; and

the second beam splitter directs more than half of the light energy received from the light source into the sample light beam and less than half of the light energy received from the light source into the reference light beam.

30. The imaging system of claim 29, further comprising a catheter and an optical fiber within the catheter, wherein the second optical path is optically coupled to the optical fiber within the catheter.

31. The imaging system of claim 28, further comprising a focusing lens, wherein the second optical path optically couples the first beam splitter to the focusing lens, to focus the sample light beam onto the sample and to focus the second sample light beam.

32. An imaging system comprising:

5 an ultrasound console having an input;

an interferometer comprising:

a low coherence light source;

a first fiber optic beam splitter;

a first optical fiber optically coupling the light source to the first beam splitter,

wherein the first beam splitter splits light received from the light source into a sample light beam and a reference light beam;

an optical circulator having a first port, a second port and a third port, wherein light input to the first port exits the optical circulator from the second port and light entering the second port exits the optical circulator from the third port;

5 a second optical fiber optically coupling the first beam splitter to the first port of the optical circulator;

a third optical fiber optically coupling the second port of the optical circulator to a sample and optically coupling a second sample light beam from the sample to the second port;

a second beam splitter;

20 a fourth optical fiber optically coupling the third port of the optical circulator to the second beam splitter, wherein the third optical fiber conveys the second sample light beam, at least in part, from the third port to the second beam splitter;

a diffraction grating;

a fifth optical fiber optically coupling the first beam splitter to the diffraction grating to convey the reference light beam, at least in part, to the diffraction grating;

the second beam splitter being positioned to receive the diffracted reference light beam from the diffraction grating, wherein the reference light beam and the second sample light beam combine in the beam splitter to form a combined light beam; and

a multi-element photo detector positioned to receive the combined beam, the multi-element photo detector having a plurality of parallel outputs; and

the system further comprising a parallel to serial converter comprising a plurality of inputs, each input being coupled to a respective one of the plurality of outputs of the detector, to convert the parallel data output by the plurality of outputs of the detector into serial data,

the parallel to serial converter having an output coupled to the input of the ultrasound console to provide the serial data to the ultrasound console to process into an image.

33. The imaging system of claim 32, wherein the light received from the light source has an energy and the first beam splitter splits the light into a sample light beam having more than half of the energy of the light and a reference light beam having less than half of the energy of the light.

34. The imaging system of claim 33, wherein the second beam splitter is an approximately 50/50 beam splitter and the second sample light beam and the reference light beam are combined in the second beam splitter to form first and second sample light beams, wherein the first combined light beam is received by the first multi element photo detector; and

the interferometer further comprises a second multi-element photo detector positioned to receive a second combined beam from the second beam splitter, the second multi-

element photo detector comprising a plurality of parallel outputs coupled to the parallel to serial converter.

35. The imaging system of claim 34, further comprising a catheter and an optical fiber within the catheter, wherein the third optical fiber is optically coupled to the optical fiber within the catheter.

36. The imaging system of claim 32, further comprising a catheter and an optical fiber within the catheter, wherein the third optical fiber is optically coupled to the optical fiber within the catheter.

37. The imaging system of claim 32, further comprising a focusing lens to focus the sample light beam from the third optical fiber onto the sample and to focus the second sample light beam into the third optical fiber.

38. A method of analyzing a surface comprising the step of:
processing data from an interferometer by an ultrasound processor into an image for display.

39. The method of claim 38, further comprising the steps of:
forming a sample light beam and a reference light beam by an interferometer;
conveying the sample light beam to the surface;
combining light received from the surface with the reference light beam into a combined light beam;
detecting the combined light beam with a multi-element detector to output a plurality of parallel electrical signals;
converting the processed parallel electrical signals into a serial signal; and

providing the serial signal to the ultrasound processor for processing into an image.

40. The method of claim 39, further comprising the steps of:

coupling an interferometer to the ultrasound console prior to the processing step;

decoupling the interferometer from the ultrasound console after the processing

step; and

coupling an ultrasound device to the ultrasound console.